

3'-END NUCLEOSIDE UNIT COMPRISING PHOSPHORAMIDITE

FIELD OF THE INVENTION

[0001]

5 The invention relates to a 3'-end nucleoside unit that is be  
advantageously used in a phosphoramidite method without  
protecting a base moiety, which was developed by the present  
inventors.

10 BACKGROUND ART

[0002]

In conventional DNA synthesis methods, the introduction of a  
3'-end nucleoside unit on a solid-phase support was done by the  
formation of amide bond with an amino group on the solid-phase  
15 support using a linker such as a succinate linker or silyl  
linkers for the 3'-end nucleoside.

[0003]

For example, a benzoic acid-type compound:  $iP_2Si-C_6H_4-C(O)-$  type  
that was developed by one of the present inventors, SEKINE  
20 Mitsuo, is known as a silyl linker that can be cut out under  
a neutral condition (Non-Patent Document 1). However, since  
such silyl linker will be introduced into amino groups on the  
solid-phase support by acylation, the amino groups contained  
in dA, dC and dG have to be protected in advance with an  
25 appropriate protecting group such as DMTr.

[0004]

Furthermore, as the DMTr protecting group in the base moiety of dC is relatively stable, treatment with 5% trifluoroacetic acid-CH<sub>2</sub>Cl<sub>2</sub> solution for 30 min would be required to completely remove said protecting group. However, SiO bonds contained in the silyl linker and those formed between the silyl linker and a synthesized DNA oligomer would likely be cleaved under such a very acidic condition as in the above treatment.

[0005]

Non-Patent Document 1: Wada, T.; Mochizuki, A.; Sato, T.; Seike, M.; M., Tetrahedron Letters, 1998, 39, 5593-5596

#### SUMMARY OF THE INVENTION

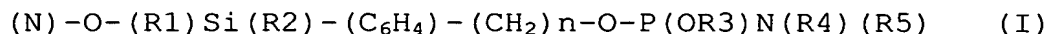
Problems to be solved by the invention

[0006]

The purpose of the present invention is therefore to provide a method for binding a 3'-end nucleoside unit comprising any base to a hydroxyl group on a solid-phase support under completely the same condition as in DNA chain elongation reaction. Thus, as the DNA chain elongation reaction can be carried out with almost 100 % reaction efficiency, the present inventors have studied hard in order to enable the introduction reaction of the 3'-end nucleoside unit on the solid-phase support under the same condition. Finally, the present inventors have solved the above problems by introducing a silyl linker and a phosphoramidite group into the 3'-end nucleoside unit and have completed the present invention.

[0007]

The present invention relates to a 3'-end nucleoside unit comprising phosphoramidite that is a compound represented by the following formula:



wherein (N) represents any nucleoside or its derivative, each of R<sub>1</sub>, R<sub>2</sub>, R<sub>4</sub> and R<sub>5</sub> is an alkyl or aryl group, R<sub>3</sub> is a phosphate-protecting group, and n is an integer of from 1 to

5.

[0008]

The present invention further relates to a solid-phase support having said 3'-end nucleoside unit, for example, at a ratio of 20-30  $\mu\text{mol/g}$ ; to a method for the synthesis of a nucleic acid oligomer with the use of said solid-phase support, especially, to a phosphoramidite method with the use of an activating agent comprising an alcohol-type compound, or a mixture of the alcohol-type compound and an acid catalyst.

Advantages of the invention

[0009]

The solid-phase supports having hydroxyl groups on their surfaces are now available by using the 3'-end nucleoside unit comprising the phosphoramidite according to the present invention. DNA synthesized with the use of the above phosphoramidite unit would be hardly cut out even under a basic

condition such as with ammonia in contrast to the conventional methods. Furthermore, if the phosphoramidite unit comprising the silyl inker according to the present invention is used in the phosphoramidite method without the protecting base moiety, which was developed by the present inventors, no protecting group for the base moiety of the nucleic acids will be necessary in a process of the introduction of the nucleoside on the solid-phase support.

10 Brief description of drawing

[0010]

Fig. 1 shows a chart in an anion-exchange HPLC of DNA oligomer.

Best Mode for Carrying out the Invention

15 [0011]

The silyl group may have any substituents of R1 and R2 known for those skilled in the art, such as, for example, an alkyl group having 1 to 5 carbon atoms or an aryl group such as benzyl, phenyl and naphthyl group, which may have a substituent of the above alkyl, nitro, cyano, halogeno or alkoxy group at any position.

[0012]

Any phosphate-protecting group known for those skilled in the art may be used, 2-cyanoethyl, 4-nitrophenylethyl,

25 N-(trifluoroacetyl)aminobutyl, or

4-[N-methyl-N-(2,2,2-trifluoroacetyl)amino]butyl group being

preferable.

[0013]

R4 and R5 in the above formula are an alkyl having 1 to 4 carbon atoms, or aryl such as benzyl, phenyl and naphthyl group, an isopropyl group being preferable.

[0014]

Furthermore, the benzene ring structure of the present compound may have any substituent known for those skilled in the art, which, for example, is selected from the group consisting of alkyl having 1 to 4 carbon atoms, halogeno, nitro, cyano and methoxy groups. The groups of "-CONH-" and "Si" are bound to the benzene ring in a para-position.

[0015]

The compound of the present invention may be easily synthesized by those skilled in the art with reference to the following examples. Conditions that are not specifically described in the present specification may be optionally selected by those skilled in the art.

## Examples

[0016]

The present invention will be explained more in detail in line with the examples, which should not be construed to impose any limitations on the scope of the present invention.

[0017]

4-diisopropylsilanylbenzoic acid methyl ester (2)

4-diisopropylsilanylbenzoic acid (9 g, 38 mmol) was dissolved in methanol (300 mL), and conc.  $\text{H}_2\text{SO}_4$  (15 mL) was added dropwise to the solution cooled on ice. After being heated to reflux for 2 hours, the reaction solution was dissolved in chloroform (500 mL). The solution was then extracted two times with water (300 mL) and three times with 5 wt% aqueous solution (300 mL) of sodium hydrogen carbonate. An organic layer was collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography. After eluted with hexane having 0-5 % ethyl acetate gradient, the solvent was distilled out to give a desired product (8.8 g, 93 %). Its NMR data are as follows:

[0018]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.93-1.06 (m, 12H), 1.18-1.27 (m, 2H), 3.90 (s, 3H), 3.96 (t, 1H,  $J = 3.2$  Hz), 7.58 (d, 2H,  $J = 8.1$  Hz), 7.98 (d, 2H,  $J = 8.1$  Hz).

$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 10.6, 18.5, 18.6, 52.2, 128.1, 128.2, 128.3, 130.5, 140.6, 167.1.

[0019]

4-(hydroxymethyl)phenyl-diisopropylsilane (3)

$\text{LiAlH}_4$  (1.2 g, 32 mmol) was dissolved in anhydrous THF (80 mL), and to this was slowly added dropwise the anhydrous THF solution

(80 mL) 4-diisopropylsilanylbenzoic acid methyl ester (2) (8 g, 32 mmol). The resulting mixture was then stirred for 10 min and ethyl acetate (20 mL) was added slowly to it. The reaction mixture was diluted with dichloromethane (500 mL), and then  
5 extracted three times with 0.2 N hydrochloric acid aqueous solution (400 mL). An organic layer was collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure to give a desired product (7.2 g, quant). Its NMR data are  
10 as follows:

[0020]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 1.02 (2d, 12H,  $J = 7.3$  Hz), 1.17-1.23 (m, 2H), 3.09 (brs. 1H), 3.94 (t, 1H,  $J = 3.2$  Hz), 4.58 (s, 2H), 7.29 (d, 2H,  $J = 7.6$  Hz), 7.48 (d, 2H,  $J = 7.6$  Hz).

15  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 10.7, 18.4, 18.6, 64.8, 126.0, 132.9, 135.4, 141.6.

[0021]

4-(acetoxymethyl)phenyl-diisopropylsilane (4)

Acetic anhydride (3.1 mL, 33 mmol) and

20 4-N,N-dimethylaminopyridine (7.3 mg, 6 mmol) were added under argon atmosphere to pyridine (100 mL) dissolving 4-(hydroxymethyl)phenyl-diisopropylsilane (3) (4.9 g, 22 mmol). The resulting mixture was then stirred for 2 hours at a room temperature and methanol (20 mL) was added to it. The  
25 reaction mixture was diluted with ethyl acetate (400 mL), and then extracted three times with saturated saline solution (300

mL). An organic layer was collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure to give a desired product (5.4 g, 93 %). Its NMR data are as follows:

5 [0022]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 1.03 (2d, 12H,  $J = 7.0$  Hz), 1.20-1.24 (m, 2H), 2.09 (s, 3H), 3.96 (t, 1H,  $J = 3.1$  Hz), 5.10 (s, 2H), 7.32 (d, 2H,  $J = 8.1$  Hz), 7.51 (d, 2H,  $J = 8.1$  Hz).

$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 10.7, 18.4, 18.6, 20.9, 66.1, 127.1, 134.0,  
10 135.5, 136.5, 170.4.

[0023]

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(acetoxymethyl) phenyl-diisopropylsilyl] thymidine (5t)

1,3-dichloro-4,4-dimethylhydantoin (761 mg, 3.9 mmol) was  
15 added to anhydrous  $\text{CH}_2\text{Cl}_2$  solution (10 mL) of  
4-(acetoxymethyl)phenyl-diisopropylsilane (4) (508 mg, 1.9  
mmol). The resulting mixture was then stirred for 30 min at  
a room temperature and added to anhydrous  $\text{CH}_2\text{Cl}_2$  solution (10  
mL) dissolving 5'-O-(4,4'-dimethoxytrityl)thymidine (954 mg,  
20 1.8 mmol) and imidazole (595 mg, 8.8 mmol). The reaction  
mixture was stirred for 30 min at a room temperature and mixed  
with water (5 mL). After 5 min, the reaction mixture was diluted  
with chloroform (100 mL) and extracted three times with 5 wt%  
aqueous solution (100 mL) of sodium hydrogen carbonate. An  
25 organic layer was collected and dehydrated with anhydrous  
sodium sulfate and filtered so that the resulting solvent was



distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography (1% pyridine). After eluted with hexane having 50-100 % chloroform gradient and chloroform having 0-3 % methanol gradient, the solvent was distilled out to give a desired product (1.1 g, 75 %). Its NMR data are as follows:

[0024]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.95-1.07 (m, 12H), 1.18-1.26 (m, 2H), 1.53 (s, 3H), 2.09 (s, 3H), 2.27-2.31 (m, 1H), 2.48-2.56 (m, 1H), 3.39 (d, 1H,  $J = 8.1$  Hz), 3.50 (d, 1H,  $J = 8.6$  Hz), 3.75 (s, 6H), 4.16 (d, 1H,  $J = 2.4$  Hz), 4.67 (d, 1H,  $J = 5.7$  Hz), 5.11 (s, 2H), 6.51 (t, 1H,  $J = 4.1$  Hz), 6.82 (dd, 4H,  $J = 2.4$  Hz,  $J = 8.9$  Hz), 7.18-7.67 (m, 14H), 10.3 (brs, 1H).

$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 11.7, 11.8, 11.9, 12.4, 16.8, 17.1, 17.16, 17.19, 17.21, 20.7, 41.6, 54.9, 63.1, 65.8, 73.1, 77.2, 84.7, 86.6, 86.8, 110.8, 112.9, 123.4, 124.9, 126.7, 126.9, 127.1, 127.6, 127.7, 127.8, 129.7, 133.3, 134.1, 134.4, 134.97, 135.01, 135.2, 135.7, 136.5, 143.9, 149.1, 150.3, 158.3, 163.9, 170.4.

MS  $m/z$  calcd for  $\text{M}+\text{Na}$ ; 829.3496. Found; 829.3452

[0025]

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(acetoxymethyl) phenyl-diisopropylsilyl], 2-deoxyadenosine (5a)

4-(acetoxymethyl)phenyl-diisopropylsilane (4) (420 mg, 1.6 mmol) was dissolved in anhydrous  $\text{CH}_2\text{Cl}_2$  solution (8 mL), and 1,3-dichloro-4,4-dimethylhydantoin (629 mg, 3.2 mmol) was added to it. The resulting mixture was then stirred for 30 min

at a room temperature and added to anhydrous  $\text{CH}_2\text{Cl}_2$  solution (8 mL) dissolving

5'-O-(4,4'-dimethoxytrityl)-2'-deoxyadenosine (796 mg, 1.4 mmol) and imidazole (489 mg, 7.2 mmol). The reaction mixture

5 was stirred for 30 min at a room temperature and mixed with water (5 mL). After 5 min, the reaction mixture was diluted with chloroform (100 mL) and extracted three times with 5 wt% aqueous solution (100 mL) of sodium hydrogen carbonate. An organic layer was collected and dehydrated with anhydrous sodium  
10 sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography (1% pyridine). After eluted with hexane having 50-100 % chloroform gradient and chloroform having 0-3 % methanol gradient, the solvent was  
15 distilled out to give a desired product (850 mg, 72 %). Its NMR data are as follows:

[0026]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.98-1.07 (m, 12H), 1.22-1.31 (m, 2H), 2.11 (s, 3H), 2.48-2.55 (m, 1H), 2.75-2.89 (m, 1H), 3.31 (d, 1H,  $J = 4.6$  Hz), 3.38 (d, 1H,  $J = 4.6$  Hz), 3.76 (s, 6H), 4.28 (d, 1H,  $J = 2.4$  Hz), 4.67 (t, 1H,  $J = 2.6$  Hz), 5.10 (s, 2H), 6.09 (s, 1H), 6.50 (dd, 1H,  $J = 5.9$  Hz,  $J = 7.3$  Hz), 6.76 (d, 4H,  $J = 8.6$  Hz), 7.17-7.38 (m, 11H), 7.50 (d, 2H,  $J = 7.3$  Hz), 7.99 (s, 1H), 8.28 (s, 1H).

25  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 12.1, 12.2, 17.4, 21.0, 40.9, 55.2, 63.5, 66.1, 73.5, 84.5, 86.4, 87.1, 112.9, 113.0, 119.9, 126.7, 127.2, 127.7,

128.0, 129.9, 133.7, 134.6, 135.48, 135.51, 137.0, 138.8, 144.3,  
149.4, 152.6, 155.3, 158.3, 170.6

MS m/z calcd for M+H; 816.3793. Found; 816.3711.

5 [0027]

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(hydroxymethyl)  
phenyl-diisopropylsilyl] thymidine (6t)

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(acetoxymethyl)  
phenyl-diisopropylsilyl] thymidine (5t) (925 mg, 1.2 mmol) was  
10 treated with tBuNH<sub>2</sub>-MeOH (1:4, v/v, 20 mL) for 3 hours at a room  
temperature. The reaction mixture was diluted with chloroform  
(100 mL), and then extracted three times with saturated saline  
solution (100 mL). An organic layer was collected and  
dehydrated with anhydrous sodium sulfate and filtered so that  
15 the resulting solvent was distilled out under a reduced pressure.  
The resulting crude product was then purified by silica gel  
column chromatography (1% pyridine). After eluted with hexane  
having 50-100 % chloroform gradient and chloroform having 0-3 %  
methanol gradient, the solvent was distilled out to give a  
20 desired product (781 mg, 89 %). Its NMR data are as follows:

[0028]

<sup>1</sup>H NMR (CDCl<sub>3</sub>): 0.92-1.00 (m, 12H), 1.17-1.25 (m, 2H), 1.56 (s,  
3H), 2.15-2.38 (m, 1H), 2.53-2.68 (m, 1H), 3.31 (dd, 1H, J =  
2.7 Hz, J = 10.5 Hz), 3.43 (dd, 1H, J = 2.7 Hz, J = 10.5 Hz),  
25 3.77 (s, 6H), 4.12 (d, 1H, J = 2.4 Hz), 4.63 (t, 1H, J = 2.7  
Hz), 4.67 (d, 1H, J = 5.7 Hz), 6.44 (dd, 1H, J = 5.9 Hz, J =

7.3 Hz), 6.77 (dd, 4H,  $J = 2.4$  Hz,  $J = 8.9$  Hz), 7.19–7.35 (m, 11H), 7.44 (d, 2H,  $J = 7.8$  Hz), 7.61 (s, 1H), 8.15 (brs, 1H).

$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 12.0, 17.4, 41.8, 55.2, 63.3, 64.9, 73.3, 84.8, 86.8, 87.1, 111.0, 113.1, 126.1, 126.9, 127.8, 129.8, 129.9, 132.4, 134.5, 135.0, 135.2, 135.5, 142.2, 144.1, 150.3, 158.4, 163.9.

MS  $m/z$  calcd for  $\text{M}+\text{H}$ ; 787.3391. Found; 787.3413.

[0029]

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(hydroxymethyl)]

phenyl-diisopropylsilyl], 2-deoxyadenosine (6a)

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(acetoxymethyl) phenyl-diisopropylsilyl] 2-deoxyadenosine (5a) (610 mg, 0.75 mmol) was treated with  $\text{tBuNH}_2\text{-MeOH}$  (1:4, v/v, 15 mL) for 3 hours at a room temperature. The reaction mixture was diluted with chloroform (100 mL), and then extracted three times with saturated saline solution (100 mL). An organic layer was collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography (1% pyridine). After eluted with hexane having 50–100 % chloroform gradient and chloroform having 0–3 % methanol gradient, the solvent was distilled out to give a desired product (530 mg, 92 %). Its NMR data are as follows:

[0030]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.93–1.03 (m, 12H), 1.20–1.29 (m, 2H), 2.48–2.55

(m, 1H), 2.75-2.89 (m, 1H), 3.22 (dd, 1H,  $J = 4.1$  Hz,  $J = 10.3$  Hz), 3.39 (dd, 1H,  $J = 4.1$  Hz,  $J = 10.3$  Hz), 3.73 (s, 6H), 4.21 (d, 1H,  $J = 3.8$  Hz), 4.69 (s, 3H), 6.01 (s, 2H), 6.50 (t, 1H,  $J = 6.2$  Hz), 6.74 (d, 4H,  $J = 8.9$  Hz), 7.13-7.33 (m, 11H), 7.50 (d, 2H,  $J = 8.1$  Hz), 7.81 (s, 1H), 8.26 (s, 1H).

$^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 12.2, 12.3, 17.46, 17.51, 17.55, 17.6, 40.8, 55.2, 63.2, 64.9, 73.0, 77.2, 84.2, 86.4, 86.7, 113.0, 119.8, 123.6, 126.3, 126.7, 127.7, 128.0, 128.1, 128.9, 129.87, 129.9, 132.6, 134.7, 135.5, 135.6, 135.8, 138.7, 142.5, 144.4, 149.5, 149.6, 152.8, 155.3, 158.3.

MS  $m/z$  calcd for  $\text{M}+\text{H}$ ; 774.3687. Found; 774.3747.

[0031]

5'-[O-(4,4'-dimethoxytrityl)], 3'-O-[O-4-(2-cyanoethyl N,N-diisopropylphosphoramidite) benzyl-diisopropylsilyl] thymidine (7t)

5'-[O-(4,4'-dimethoxytrityl)], 3'-O-[4-O-(hydroxymethyl) phenyl-diisopropylsilyl] thymidine (6t) (770 mg, 1.0 mmol) was subjected to azeotropic distillation sequentially with pyridine, toluene and dichloromethane to be dehydrated and dissolved in anhydrous THF (10 mL). To the resulting solution was added diisopropylethylamine (242  $\mu\text{L}$ , 1.1 mmol) and (2-cyanoethyl) (N,N-diisopropylamino)chlorophosphine (242  $\mu\text{L}$ , 1.5 mmol). After being stirred for 30 min, the reaction solution was poured into water (20 mL) and diluted with chloroform (200 mL), and then extracted three times with saturated saline solution (200 mL). An organic layer was

collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography (1% triethylamine).

5 After eluted with hexane having 50-100 % chloroform gradient and chloroform having 0-3 % methanol gradient, the solvent was distilled out to give desired white solid (850 mg, 88 %). Its NMR data are as follows:

[0032]

10  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.94-1.06 (m, 12H), 1.17-1.29 (m, 15H), 1.50 (s, 3H), 2.13-2.30 (m, 1H), 2.35-2.48 (m, 1H), 2.60 (t, 2H,  $J = 6.3$  Hz), 3.27 (dd, 1H,  $J = 2.7$  Hz,  $J = 10.5$  Hz), 3.45 (dd, 1H,  $J = 2.7$  Hz,  $J = 10.5$  Hz), 3.61-3.87 (m, 10H), 4.14 (d, 1H,  $J = 2.1$  Hz), 4.65-4.76 (m, 3H), 6.48 (dd, 1H,  $J = 5.7$  Hz,  $J = 7.8$  Hz), 6.80 (dd, 4H,  $J = 2.4$  Hz,  $J = 8.9$  Hz), 7.21-7.37 (m, 11H), 7.46 (d, 2H,  $J = 7.6$  Hz), 7.63 (s, 1H), 9.45 (brs, 1H).  
 $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 11.8, 11.9, 12.0, 12.4, 16.9, 17.1, 17.27, 17.32, 17.4, 20.3, 20.4, 22.8, 22.90, 22.94, 24.47, 24.55, 24.57, 24.7, 41.7, 43.0, 43.2, 45.2, 45.3, 55.1, 58.3, 58.5, 63.3, 65.0, 65.3, 67.8, 73.2, 77.2, 84.8, 86.7, 87.0, 110.9, 113.01, 113.04, 117.4, 126.0, 126.1, 126.8, 127.7, 127.8, 129.76, 129.80, 132.3, 134.0, 134.3, 135.0, 135.2, 135.4, 140.2, 140.3, 144.0, 150.2, 158.4, 163.8.

$^{31}\text{P}$  NMR ( $\text{CDCl}_3$ ): 149.3

25 [0033]

5'-[O-(4,4'-dimethoxytrityl)], 3'-O-[4-O-(2-cyanoethyl]

N,N-diisopropylphosphoramidite) benzyl-diisopropylsilyl]  
2'-deoxyadenosine (7a)

5'-[O-(4,4'-dimethoxytrityl)], 3'-[O-4-(hydroxymethyl)  
 phenyl-diisopropylsilyl] 2'-deoxyadenosine (6a) (450 mg, 0.58

5 mmol) was subjected to azeotropic distillation sequentially  
 with pyridine, toluene and dichloromethane to be dehydrated  
 and dissolved in anhydrous THF (6 mL). To the resulting  
 solution was added diisopropylethylamine (144  $\mu$ L, 0.64 mmol).  
 The resulting solution was cooled to  $-78^{\circ}\text{C}$ , mixed with  
 10 (2-cyanoethyl) (N,N-diisopropylamino)chlorophosphine (141  $\mu$ L,  
 0.87 mmol) and then gradually brought back to a room temperature.  
 After being stirred for 30 min, the reaction solution was poured  
 into water (20 mL) and diluted with chloroform (200 mL), and  
 then extracted three times with saturated saline solution (200  
 15 mL). An organic layer was collected and dehydrated with  
 anhydrous sodium sulfate and filtered so that the resulting  
 solvent was distilled out under a reduced pressure. The  
 resulting crude product was then purified by silica gel column  
 chromatography (1% triethylamine). After eluted with hexane  
 20 having 50-100 % chloroform gradient and chloroform having 0-3 %  
 methanol gradient, the solvent was distilled out to give desired  
 white solid (500 mg, 87 %). Its NMR data are as follows:

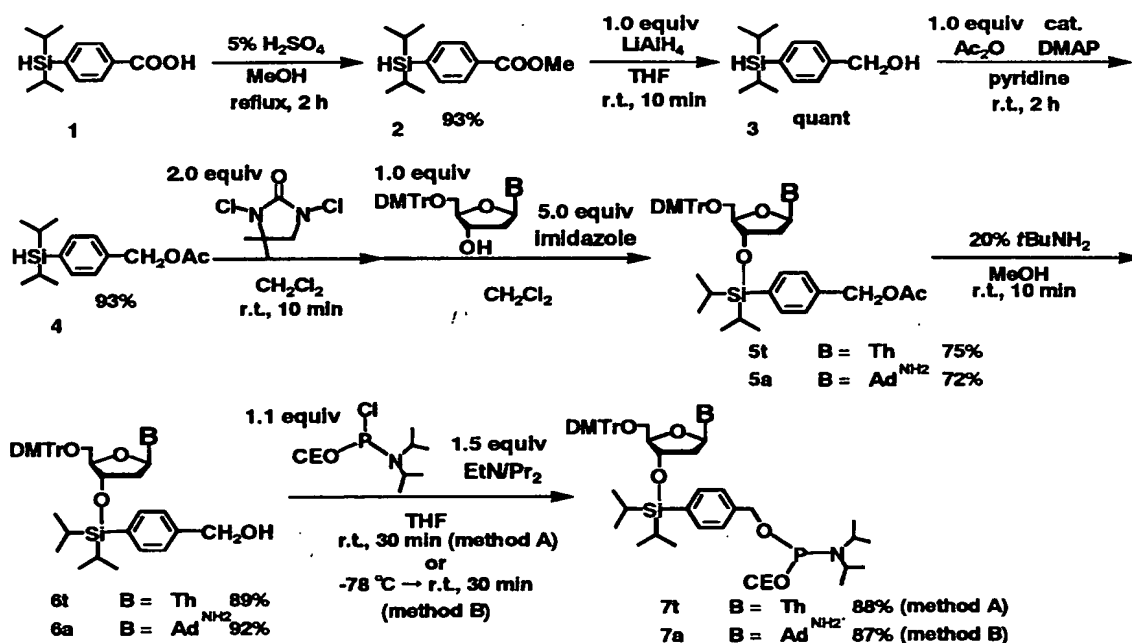
[0034]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 0.98-1.05 (m, 12H), 1.16-1.29 (m, 15H),  
 25 2.48-2.69 (m, 3H), 2.72-2.87 (m, 1H), 3.31 (dd, 1H,  $J = 4.1$  Hz,  
 $J = 10.3$  Hz), 3.39 (dd, 1H,  $J = 4.1$  Hz,  $J = 10.3$  Hz), 3.60-3.86

(m, 10H), 4.28 (d, 1H,  $J = 2.4$  Hz), 4.67–4.78 (m, 3H), 6.06 (s, 2H), 6.51 (t, 1H,  $J = 6.4$  Hz), 6.77 (d, 4H,  $J = 8.6$  Hz), 7.18–7.38 (m, 11H), 7.49 (d, 2H,  $J = 7.0$  Hz), 7.98 (s, 1H), 8.28 (s, 1H).  
 $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ ): 12.2, 12.3, 17.46, 17.51, 17.55, 17.6, 40.8, 55.2, 63.2, 64.9, 73.0, 77.2, 84.2, 86.4, 86.7, 113.0, 119.8, 123.6, 126.3, 126.7, 127.7, 128.0, 128.1, 128.9, 129.87, 129.9, 132.6, 134.7, 135.5, 135.6, 135.8, 138.7, 142.5, 144.4, 149.5, 149.6, 152.8, 155.3, 158.3.  
 $^{31}\text{P}$  NMR ( $\text{CDCl}_3$ ): 149.3.

10 [0035]

[Chemical formula 1]



[0036]

Triethylammonium, O-(4,4'-dimethoxytrityl) acetic acid (9)

15 4,4'-dimethoxytrityl chloride was added to pyridine solution



(100 mL) dissolving hydroxyacetic acid (760 mg, 10 mmol) and triethylamine (1.45 mL, 11 mmol). Stirring for 24 hours at a room temperature gave 20 mL of ethanol, which was diluted with chloroform (500 mL) and extracted three times with 0.5 M triethylammonium carbonate buffer (300 mL). An organic layer was collected and dehydrated with anhydrous sodium sulfate and filtered so that the resulting solvent was distilled out under a reduced pressure. The resulting crude product was then purified by silica gel column chromatography. After eluted with chloroform having 0-3 % methanol gradient, the solvent was distilled out to give a desired product (3.5 g, 73 %). Its NMR data are as follows:

[0037]

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ): 1.15 (t, 9H,  $J = 7.3$  Hz), 2.97 (dd, 6H,  $J = 7.0$  Hz,  $J = 14.9$  Hz), 3.55 (s, 2H), 3.64 (s, 6H), 6.77 (dd, 4H,  $J = 2.4$  Hz,  $J = 7.0$  Hz), 7.06-7.17 (m, 3 H), 7.39 (dd, 4H,  $J = 2.0$  Hz,  $J = 7.4$  Hz), 7.43 (d, 2H,  $J = 1.4$  Hz).

[0038]

#### Preparation of a solid-phase support (10)

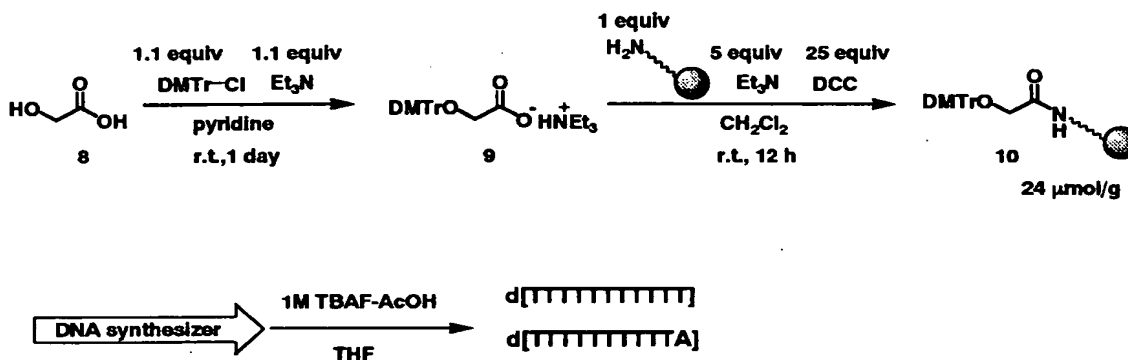
Solid-phase support (highly cross-linked polystyrene:HCP) sufficiently dried (500 mg, 17  $\mu\text{mol}$ ), triethylammonium, O-(4,4'-dimethoxytrityl)acetic acid 3-18 (260  $\mu\text{mol}$ ) and DCC (268 mg 1.3 mmol) were dissolved into dichloromethane (5 mL) and stirred for 12 hours at a room temperature. After the completion of the reaction, the solid-phase support was filtered, washed with acetonitrile, dried and added to pyridine

solution (4.5 mL) of acetic anhydride (0.5 ml) and DMAP (5 mg). After being stirred for 3 hours, the solid-phase support was filtered again and washed with acetonitrile. The introduction ratio of the compound was measured by colorimetric

5 determination of the trityl group (24  $\mu\text{mol/g}$ ).

[0039]

[Chemical formula 2]



[0040]

#### 10 DNA synthesis with the use of the silyl linker

The synthesis of  $\text{d}[\text{TTTTTTTTTT}]$  and  $\text{d}[\text{TTTTTTTTTTA}]$  was carried out with the use of the HCP solid-phase support (1  $\mu\text{mol}$ , 24  $\mu\text{mol/g}$ ) and the phosphoramidite unit (7t) or (7a) comprising the silyl linker, or thymidine 3' phosphoramidite unit by means

15 of DNA/RNA Synthesizer 392 (Applied Biosystem Inc.:ABI).

Each elongation cycle of the oligomer was shown in TABLE 1 below.

[0041]

[TABLE 1]

step	operation	Reagent(s)	time, (min)
1	washing	CH <sub>3</sub> CN	0.2
2	deprotection	3% Cl <sub>3</sub> CCOOH / CH <sub>2</sub> Cl <sub>2</sub>	1.5
3	washing	CH <sub>3</sub> CN	0.4
4	coupling	0.1M amidite + 0.2M HO <sup>t</sup> Bt in CH <sub>3</sub> CN-NMP (15:1, v/v)	1.0
5	washing	CH <sub>3</sub> CN	0.2
6	coupling	0.1M amidite + 0.2M HO <sup>t</sup> Bt in CH <sub>3</sub> CN-NMP (15:1, v/v)	1.0
7	washing	CH <sub>3</sub> CN	0.2
8	oxidation	0.1M I <sub>2</sub> in Py-H <sub>2</sub> O-THF (20:2:78, v/v/v)	0.5
9	washing	CH <sub>3</sub> CN	0.4

[0042]

The DMTr group was then removed by the treatment with 3 % trichloroacetic acid in CH<sub>2</sub>Cl<sub>2</sub> (2 mL) for one minute, and the solid-phase support was washed with CH<sub>2</sub>Cl<sub>2</sub> (1 mL x 3) and CH<sub>3</sub>CN (1 mL x 3). The cyanoethyl group was then removed by the treatment with 10% DBU in CH<sub>3</sub>CN (500 μL). After being washed with CH<sub>3</sub>CN (1 mL x 3), the solid-phase support was treated with anhydrous THF solution (500 μL) dissolving TBAF (131 mg, 0.5 mmol) and acetic acid (24 μL, 0.5 mmol) for one hour in order to cut out the DNA oligomer. The resulting mixture solution was desalted with Sep-Pak C18 cartridge to give a desired product.

## 15 Industrial applicability

[0043]

Various solid-phase material may be selected by using the 3'-end nucleoside unit comprising phosphoramidite according to the present invention, making it possible to synthesize a high through-put DNA chip wherein the solid-phase may be directly

used as the chip.